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THEORY AND PRACTICE: WEED MANAGEMENT IN NO TILLAGE SOYBEANS

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Introduction

Recent changes in government policy and concerns for soil conservation have resulted in considerable interest in no tillage soybean production. Further, there has been a coincidental shift in narrow row production. These efforts represent an interest to increase the amount of plant residue left intact on the soil surface after planting thus reducing soil erosion and an attempt to manipulate row spacing to improve soybean yield potential. However, growers intuitively recognize that weed management becomes increasingly challenging as the amount of soil disturbance is decreased. The difficulty in weed management when seed bed preparation tillage is eliminated is the result in a shift in the field ecology that generally favors the development of weeds over crops. An understanding of the factors involved in this ecological shift is critical if effective weed management systems are to be developed for no tillage soybean production. This paper will discuss these ecological factors and describe management strategies that will effectively control weeds in no tillage soybean production.

The No Tillage Field Environment

The major change in the field environment when preplant tillage is eliminated is the increased plant residue left on the soil surface. The plant residue is the critical factor in reducing soil erosion and in changing the field environment. Plant residue must be managed if successful soybean production without tillage is to be accomplished. There are several ways that plant residue impacts the field environment. Direct effects of plant residue on the field environment are changes in soil moisture, soil temperature, soil organic matter, soil chemical characteristics and sunlight penetration onto the soil surface. Indirect effects of plant residue on the field environment include changes in soil microflora, weed seed distribution and herbicide placement.

The effect of plant residue on soil moisture is an important factor on soybean and weed development. Typically, soil moisture availability in the seed germination zone is improved thus probability of weed seed germination is improved. Importantly, the stratification of soil moisture vertically and horizontally within the seed germination zone may be different when high amounts of plant residue are left on the soil surface. As the plant residue protects the soil from moisture evaporation, more moisture will be available immediately under the residue and less available where no residue cover exists.

A similar variability is observed when the effect of plant residue on soil temperature is considered. As with soil moisture, the plant residue "protects" the soil from sunlight by shading. Thus, when no tillage systems are compared with clean plow tillage systems, the soil temperature variability is considerably greater, vertically and horizontally, in the no tillage systems. Typically, soils under plant residues will be considerably cooler than soils exposed to sunlight. The reduced temperature impacts soybean and weed seed germination. Also, the weed spectrum is affected by the variability in soil temperatures. Generally, soils in no tillage systems will warm more slowly with greater point to point variation, thus increasing the germination period for seeds. Delayed emergence of soybean seedlings represents an agronomic problem, while the variable emergence of weeds is a critical factor in no tillage weed management.

Increased plant residue as a result of no tillage production systems will eventually increase the soil organic matter content. As organic matter increases, herbicide performance will be impacted and thus weed management strategies affected. Generally, herbicide application rates are increased when soil organic matter increases. The increased rates reflect the adsorptive characteristics of soil organic matter on herbicides. Organic matter has greater adsorptive capacity than other soil components. Thus, long-term no tillage fields may require higher amounts of soil-applied herbicides. However, soil organic matter does not change rapidly and typically it is not necessary to dramatically change herbicide application rates in response to the elimination of tillage.

While plant residues change soil chemical characteristics, the actual impact on soybean production is not well understood. It has been reported that no tillage systems causes nutrient stratification. Plant residues can also affect soil pH. As residues decay, the tendency is for soils to become more acidic. However, this change is rather slow and does not likely have an immediate impact on no tillage soybean production.

Plant residue indirectly affects the field environment by influencing the soil microflora. Decaying plant residues serve as nutrients for soil microorganisms. Further, plant residues also create a physical environment favorable for soil microorganisms due to the affect on soil moisture and temperature. Thus as plant residues increase in a production system, the soil microflora increases. The increased microbial population may affect the rate of herbicide decomposition.

The last indirect effect of plant residues on the field environment that will be discussed is the impact that plant residues has on soil-applied herbicide placement and distribution. Plant residues serve as a physical barrier to the placement and even distribution of herbicides on the soil surface. Plant residues intercept the herbicide and potentially adsorb the herbicide, thus removing it from the field environment and lessening potential weed control. The greater the amount of plant residue on the soil surface, the greater the impact. While plant residues can adsorb herbicide, the strength of the adsorption depends on temperature and period of time that the herbicide remains on the residue before a significant rainfall event.

Tillage and Weed Populations

Tillage directly impacts weed populations through the physical removal of weeds with tillage implements. Further, important indirect effects of tillage on weed populations must be considered. Tillage affects weed populations by changing weed seed profiles in the soil, changing the weed species, affecting herbicide performance and changing the physical environment of the field.

Tillage creates a relatively even distribution of weed seeds throughout the depth of tillage. When a new weed seed crop falls to the soil surface, tillage will mix the seeds into the soil; the more intense the tillage, the more even the seed distribution. Conversely, if tillage is eliminated, the seeds remain on the soil surface and will filter downward due to freeze/thaw cycles, soil cracks and water infiltration. As most weed seeds germinate in the top one half to one inch of soil, this places a very high percentage of the weed seeds in the proper germination zone. Thus, weed populations can increase quickly. However, if weeds are effectively managed, the seed germination zone will be depleted with relative rapidity.

Tillage will also influence the type of weeds that become dominant in a specific tillage system. Soybean production systems with relatively intense tillage will have a complement of small-seeded annual weeds but large-seeded broadleaf weed are also important components of the weed flora. Perennial weeds are usually not an important consideration. When tillage is eliminated, small-seeded annuals become the major weed problem and large-seeded broadleaf weeds will usually lessen in importance within several years. Small-seeded annual weeds can take advantage of the variable physical environment that typifies no tillage systems. Small-seeded annuals must germinate very shallow in the soil profile; no tillage culture favors shallow weed seed placement.

Small-seeded annual weeds generally are prolific seed producers. As the small-seeded annual weeds germinate shallow, and given the impact of tillage on the soil environmental conditions, these weeds can germinate earlier in the growing season than the large-seeded broadleaf weeds. Consequently, when the environmental conditions favor germination of large-seeded broadleaf weeds, the small-seeded annual weeds have already filled the available growth space.

Perennial weeds are better adapted to reduced tillage systems. However, perennial weeds will not suddenly appear and become major problems when no tillage soybean production is adopted. Further, with the exception of quackgrass, johnsongrass and Canada thistle, perennial weeds are not generally as competitive as annual weeds.

Strategies for No Tillage Weed Management

No single strategy will consistently control weeds in no tillage soybean production. Typically, weed management costs have been higher in no tillage systems than in reduced or

conventional tillage systems. While there is some evidence that the physical environment created by the elimination of tillage may require increasing amounts of herbicides for similar performance, generally large rate increases are warranted. The reason that weed management costs have been greater in no tillage is that growers have attempted to use the same type of management that was effective in more intense tillage production systems.

As a general statement, intense tillage creates a field environment that makes weed management easier; crops gain competitive advantage, weed seed populations are diluted throughout the depth of tillage, and herbicides have a more uniform environment in which to perform. As tillage is reduced, and ultimately eliminated, weed management becomes more difficult. Thus, management skills must be better for effective weed management in no tillage soybean production.

It is important to recognize that the same tools that are useful for weed management in intense tillage systems are the same tools that will be used in no tillage systems. However, there are a number of important considerations somewhat unique to no tillage soybean production. Effective weed management in no tillage soybean production systems must account for the changes in field environment and weed populations. When tillage is eliminated, annual weeds have a competitive advantage over soybeans that is normally absent with intense tillage systems. Thus management decisions are more critical due to increased competition from weeds. Further, the timeliness of these decisions becomes more critical than with intense tillage systems, again attributable to the shift in competitive ability for weeds in no tillage systems.

The strategies for effective weed management in no tillage soybean production must include a number of different techniques. **Cultural control strategies** such as delayed planting, narrowing of row spacing and variety selection must be considered and included when appropriate. **Mechanical control strategies** are a critical component of weed management strategies in no tillage soybean production. Unfortunately, many growers have assumed that the elimination of primary tillage also includes the elimination of mechanical weed control practices. In truth, mechanical weed control is likely more important in no tillage production systems than in clean plow systems.

The timing and relative aggressiveness of mechanical weed control practices results in a lower impact on erosion potential than tillage used for seedbed preparation. The positive impact of mechanical weed control is greater than the risk of negative attributes. In no tillage soybean production systems with appropriate row spacings, rotary hoeing and cultivation should be included. Where narrow row spacing eliminates the usefulness of a cultivator, rotary hoeing becomes a critically important component of a weed management program.

The timeliness of these strategies is also important. Weed development can change rapidly and given the advantage that weeds may have in no tillage systems, it is critical to implement

mechanical weed control strategies in a timely fashion. If not accomplished in a timely fashion, the positive effect of mechanical weed control will be lost.

Herbicidal control strategies are likely to be considered more important in no tillage soybean production systems than in other tillage systems. Unfortunately, the consistency of herbicide performance may be less than in other tillage systems, due to some of the factors discussed previously. However, with appropriate management, planning and timing, herbicide performance in no tillage soybean production can be as effective as in other systems. Herbicide application techniques that are useful in no tillage systems include early preplant (EPP), preemergence (PRE) and postemergence (POST) treatments. Generally, no single application technique will provide consistent weed management over a variety of conditions. Currently, there are herbicides available for weed management in soybeans that will effectively control all major weed problems.

Early preplant herbicide application techniques were developed by Dr. D.W. Staniforth over 25 years ago in an attempt to provide growers with an effective, inexpensive and consistent herbicide system to control weeds in no tillage crop production. The concept was developed to improve upon the lack of consistency demonstrated by preemergence herbicide systems traditionally used in no tillage systems and to allow growers use of commonly available herbicides without the need for a burndown treatment.

Preemergence herbicide treatments control annual weeds if sufficient rainfall occurs to mobilize the herbicide downward to the zone of weed seed germination prior to germination occurs. Generally, this does not happen consistently. Thus, Dr. Staniforth suggested that if a residual herbicide were applied earlier in the Spring prior to weed seed germination, performance consistency could be improved. Typically, rainfall probabilities are better earlier in the Spring and field evaluation of the application technique has demonstrated improved control efficiency.

One problem with early application is that herbicidal weed control may stop before the crop becomes competitive. This is a greater concern with soybean production than corn, given the later planting date of soybeans. Further, there may be specific weed species that the EPP herbicide treatment does not control. Thus a preemergence burndown treatment may still be required.

Burndown herbicides have provided economical control of weeds that are emerged at planting. However, with narrow row spacing, application timing of the burndown treatment is a major consideration. Burndown treatments must be applied to actively growing weeds for acceptable performance. Most no tillage soybean drills cause considerable soil disturbance and disrupt weed growth. If this disruption occurs prior to or soon after the application of the burndown treatment, poor results may occur. If a no tillage soybean drill is used, make the burndown application several days prior to planting, or delay the application until weed growth

resumes. The latter option represents some risk if subsequent rain delays entering the field after planting.

Postemergence herbicides for soybean weed management have received considerable attention with the interest in no tillage production. Currently, there are herbicides available for postemergence application that will effectively control all weeds commonly found in Iowa soybeans. However, most of these herbicides do not have residual characteristics. Thus application timing must coincide with the crop development such that the soybean crop can become competitive and provide the residual control.

Attempts to rely on a single herbicide application for broad-spectrum, season-long weed control in no tillage soybean production has not met with consistent success. Early preplant applications, if made too early will not provide long enough control after the crop emerges. Preemergence treatments have inconsistent performance due to lack of timely rain or due to differential tolerance of specific weeds. Postemergence applications will not likely control latter weed flushes, or if growers delay application to allow more weeds to germinate, may not provide effective control of larger weeds. Thus, the best strategy is to include more than one herbicide application technique. Examples would be to use a preemergence burndown treatment and follow with a postemergence application. Another effective systems would be to use an early preplant treatment and follow with a preemergence application. Mechanical control strategies should be included as appropriate, regardless of the herbicide treatments.

Conclusions

Weed management is the most critical consideration for successful no tillage soybean production. An effective weed management systems includes cultural, mechanical and herbicidal techniques. The more alternatives that are included, the greater the consistency of control and success. No tillage weed management requires better management skills than needed in a conventional tillage system. The risk of failure from poor management decisions or untimely implementation of strategies is greater in no tillage systems, particularly if soybeans are grown in narrow row culture. While many problems can be resolved with supplementary herbicide treatments, input costs would likely be prohibitive. Planning for all possible problems, with consideration given to cost and risk, will provide the best chance for effective weed management in no tillage soybean production.